

HIGHWAY RESEARCH REPORT

VISCOSITY GRADING FOR ASPHALT CEMENTS

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RESEARCH REPORT

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For Presentation at
Symposium Evaluating Asphalt
Cement Specified by Viscosity
With Those Specified by Penetration
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ABSTRACT

The development of tests for measuring consistency of paving grade asphalts in the range of 40°F to 325°F has led to the development of specifications for specifying grade requirements at 140°F. The purpose of these requirements is to provide uniformity in asphalt viscosity during placement and rolling operations and in service resistance to rutting.

It is well known that paving grade asphalts change in viscosity during mixing operations, and that asphalts from different sources change at different rates under the same conditions. Results are presented which show that a series of asphalts having original viscosities at 140°F within a narrow band had a very wide range in viscosity after a test which simulates hot mix hardening.

Studies on the relation between asphalt consistency and field "setting" properties of the paving mixture are presented. These studies involved the use of six paving grade asphalts on one contract. The field "setting" properties showed a good correlation with the recovered asphalt viscosity at 140°F. The best correlation coefficient with the recovered asphalt viscosity is the viscosity at 140°F after tests simulating mixing, namely the Standard Thin Film or the Rolling Thin Film Tests.

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INTRODUCTION

Paving grade asphalt is a thermoplastic material. This very important property of this adhesive makes it possible to coat aggregate particles at elevated temperature, and to spread and properly compact the resulting mixture to form a pavement. On the other hand, this same property may lead to detrimental increases in viscosity of the binder at low temperatures with failures caused by cracking of the pavement.

The change in consistency with temperature has been termed "temperature susceptibility" by asphalt technologists, and a great amount of research has been expended in developing test methods for measuring consistency over the broad range of temperatures encountered in the use of paving grade asphalt. Methods have been developed to measure consistency in absolute units over a temperature range from below 40°F to 325°F. However, not all of these methods are useful for control testing, especially below 77°F.

We presently measure temperature susceptibility of the asphalt at completion of manufacture. Many tend to ignore the fact that the consistency at any specified temperature and the slope of the temperature susceptibility line change during mixing, laying and service life. This means that asphalts weathering in the field at even a normal rate may have completely different low temperature characteristics than that found immediately after manufacture. Since different asphalts weather at different rates under identical field conditions, their rate of change in low temperature characteristics will also vary even though they may all have equivalent characteristics after manufacture. It is, therefore, logical to conclude that the original temperature susceptibility curve does not provide sufficient information of value in determining the service life viscosity temperature relations of the binder.

The paving engineer first becomes interested in the properties of the binder at the time of application to the aggregate in the mixer box. It is important that a properly coated mixture be attained, and consistency at the mixing temperature is a critical factor. His next interest is in the laying and compaction of the mixture. It is well known that the consistency in the range of compaction temperatures, (breakdown, pneumatic and finish rolling) will influence the densification process. Further problems involving "setting" of the paving mixture following compaction are partly influenced by the consistency of the binder at the time of and following compaction. This paper will present a laboratory and field study on viscosity grading after a test that simulates hot mix hardening.

CONSISTENCY AND THE "SETTING" PROBLEM OF ASPHALT CONCRETE

"Certain types of paving mixtures may be difficult to compact properly and after rolling may remain 'tender' for periods of up to two weeks. The 'tenderness' of the pavement immediately after construction produces problems when traffic must be carried through the work." (1)

Studies by the California Division of Highways indicate that one of the factors influencing the "setting" properties of a paving mixture is the consistency of the asphalt during placement and rolling. Previous studies (1) indicate that an asphalt viscosity range of 4000-6000 poises at 140°F will provide a satisfactory asphalt. This is based on field correlation involving presently used 85-100 grade asphalt. Independent studies by R. J. Schmidt and associates (3) have confirmed these requirements.

It is important to note that our studies as well as those of Schmidt are based on the actual viscosity of the asphalt in the paving mixture. This viscosity at any specified temperature will be different than the value for the asphalt as manufactured. Further, the rate of change is different for asphalts from different sources. This is illustrated in Figure 1 which shows the viscosities of residues from the Rolling Thin Film Test, a test which simulates hot mix hardening. We note that this series of asphalts was manufactured to comply to the AC20 grade which has a relatively narrow band for the viscosity at 140°F. However, after the Rolling Thin Film Test the range in viscosity at 140°F is 4500 to 12,000 poises. It appears that the asphalts in this group will provide different degrees of "set" in the same paving mixture.

Either the Rolling Thin Film Test or the AASHO Thin Film Test, developed by the Federal Highway Administration, may be used for simulating the mixing operation. In References 1 and 2 a good correlation is shown between these two tests. Further, Hveem, et al (4) in a report on the Zaca-Wigmore Project showed an excellent correlation between the AASHO Thin Film Oven Test results and hardening during mixing. This confirms previous work by the Federal Highway Administration. The Rolling Thin Film was also independently correlated with field mixer hardening (1) (2).

Further field studies, subsequent to publications of reports 1 and 2, have been performed in the attempt to confirm previous findings on the importance of the viscosity parameter in field "setting". The most important of these test sections was one

placed on a road through the desert area of Southern California during June 1967. This test section was placed as part of Contract 08-039334, Road 08-SBd-40-R28.4/42.1, and as part of a Federal Highway Administration's proposal to study field performance of viscosity graded asphalts.

A number of California produced asphalts with fairly wide ranges in viscosity for a constant penetration and a range in penetration for a constant viscosity were chosen for study. Also two special asphalts manufactured in connection with a California tentative specification (2) were included.

The original viscosity penetration relations for these asphalts are shown in Table A and the viscosity results after the Rolling Thin Film and Standard Thin Film Tests in Table B. All asphalts were used in a California Standard Specification Type A, 3/4" medium grading mix. The resulting mix was spread and rolled with equivalent equipment. Test sections containing asphalts 1, 2, 3, and 4 were paved on one day and asphalt 5 and 6 about three weeks later. In all cases the weather was dry and fairly warm, 66-100°F, with morning temperatures of 66-87°F.

"Setting" of the paving mixture containing the various asphalts was judged by observation during rolling, and by asking the opinion of the breakdown roller operators. The only asphalt that showed definite signs of slow "setting" was #1. There was "sticking" to both the breakdown and pneumatic rollers, and the roller operators complained of the mix feeling "mushy". There was a tendency of the roller operators to "lay back" in attempting to roll the mixture. None of these observations were noted with asphalts 2, 3, 4, 5, and 6. The same roller man commented that asphalt #5 rolled out in an excellent manner.

The field "setting" ratings are compared with the original viscosity, viscosities after tests simulating the mixer hardening, and recovered asphalt from mix immediately after mixing in Table C. Also shown in the table are the original and recovered penetration results. We note the good correlation between the recovered asphalt viscosity at 140°F and the field "setting" properties. As shown in Tables D and E the best correlation coefficient with the recovered asphalt viscosity is the viscosity after tests simulating mixing, namely the Standard Thin Film or the Rolling Thin Film Tests.

Other field trials appear to indicate that an asphalt having a viscosity range, after a simulated mixer hardening test, of 3500-5500 poises at 140°F and a viscosity range of 300-700 centistokes at 275°F should provide paving mixtures of satisfactory "setting" qualities during paving under high atmospheric temperatures. One of the real advantages of this proposal is the uniformity of asphalt viscosity during laying and

compaction. It also permits the producer to start with a harder or softer grade in order to make an asphalt of common viscosity range during paving operations.

The proposal to grade asphalts at elevated temperatures either in the original state or after tests which simulate mixer hardening has been criticized on the basis that control is lost over low temperature consistency. This may be responsible for cracking of asphalt concrete pavements under low temperature conditions.

We are in agreement that some form of low temperature consistency requirement is needed, and that the presently used penetration test at 77°F is the best test available for routine control. However, we also believe that there is a need for a minimum penetration after a test that simulates hot mix hardening. This will provide an effective means to prevent the manufacture of asphalts complying with elevated viscosity requirements, but having high temperature susceptibility leading to very high viscosities at low temperature.

In summary, the paving engineer should be provided with asphalts which are within a uniform range of consistency during laying and compaction operations. We believe that this can only be done by specifying consistency measurements on the asphalt after it has been subjected to simulated hot mix hardening.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Federal Highway Administration.

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2. J. Skog, "Setting and Durability Studies on Paving Grade Asphalts", Proceedings of the Association of Asphalt Paving Technologists, Vol. 36, p. 387, 1967.
3. L. E. Santucci and R. J. Schmidt, "Laboratory Methods for Grading Setting Qualities of Paving Asphalts", American Society for Testing Materials, Symposium on "Grading of Paving Asphalts by Viscosities at 140°F Versus Penetrations at 77°F", ASTM Meeting, Atlantic City, June 1966.
4. F. N. Hveem, E. Zube and J. Skog, "Progress Report on the Zaca-Wigmore Experimental Asphalt Test Project", ASTM Special Technical Publication No. 277.

TABLE A

Original Viscosity Penetration Relation
for Asphalts Used on Contract 08-039334

| Asphalt No. | Grade | Penetration 77°F | Viscosity 140°F |
|----------------|---------|---------------------|--------------------|
| 1 | AC12 | 84 | 1102 |
| 2 | AC12 | 119 | 1029 |
| 3 | 85-100 | 90 | 1471 |
| 4 | 85-100 | 80 | 1042 |
| 5 | Special | 75 | 1734 |
| 6 | Special | 107 | 1067 |

TABLE B

Viscosity Results After the Rolling Thin
Film and Standard Thin Film Tests for
Asphalts Used on Contract 08-039334

| Asphalt No. | Grade | Viscosity - 140°F | |
|----------------|---------|-------------------|----------|
| | | RTF Test | STF Test |
| 1 | AC12 | 1801 | 1889 |
| 2 | AC12 | 2884 | 3273 |
| 3 | 85-100 | 3955 | 4545 |
| 4 | 85-100 | 2397 | 2881 |
| 5 | Special | 4346 | 4316 |
| 6 | Special | 2688 | 2767 |

TABLE C

Comparison of Penetration and Viscosity
Results With Field "Setting" Evaluation
Contract 08-039334

| Asph. No. | Grade Grade | Orig. Pen. 77°F | Viscosity - 140°F | | | Abson Rec. Test Results | | Field "Setting" Evaluation |
|--------------|----------------|-----------------------|-------------------|--------------|--------------|----------------------------|------------|----------------------------------|
| | | | Orig. | After STF | After RTF | Pen-77°F | Visc-140°F | |
| 1 | AC12 | 84 | 1102 | 1889 | 1808 | 59 | 2014 | Slow |
| 2 | AC12 | 119 | 1029 | 3273 | 2884 | 68 | 3732 | Satisfactory |
| 3 | 85-100 | 90 | 1471 | 4545 | 3955 | 47 | 4909 | Fast |
| 4 | 85-100 | 80 | 1042 | 2881 | 2397 | 50 | 2914 | Satisfactory |
| 5 | Special | 75 | 1734 | 4316 | 4346 | 50 | 5165 | Fast |
| 6 | Special | 107 | 1067 | 2767 | 2688 | 66 | 3136 | Satisfactory |

TABLE D

Correlation Coefficients for Comparison of
Recovered Asphalt Viscosity With Original
Viscosity and Viscosity After STF and RTF Tests

| Viscosity - 140°F | C.C. |
|-------------------|------|
| Original | .833 |
| After STF Test | .985 |
| After RTF Test | .992 |

TABLE E

Correlation Coefficients for Comparison of Recovered
Asphalt Penetration With Original Penetration, Original
Viscosity and Viscosity After STF and RTF Tests

| Viscosity - 140°F | C.C. |
|-------------------|------|
| Original | .648 |
| After STF Test | .546 |
| After RTF Test | .491 |
| Orig. Pen. | .834 |

CHANGE IN KINEMATIC VISCOSITY AFTER CALIFORNIA
ROLLING THIN FILM TEST
AC Series-Grade AC20

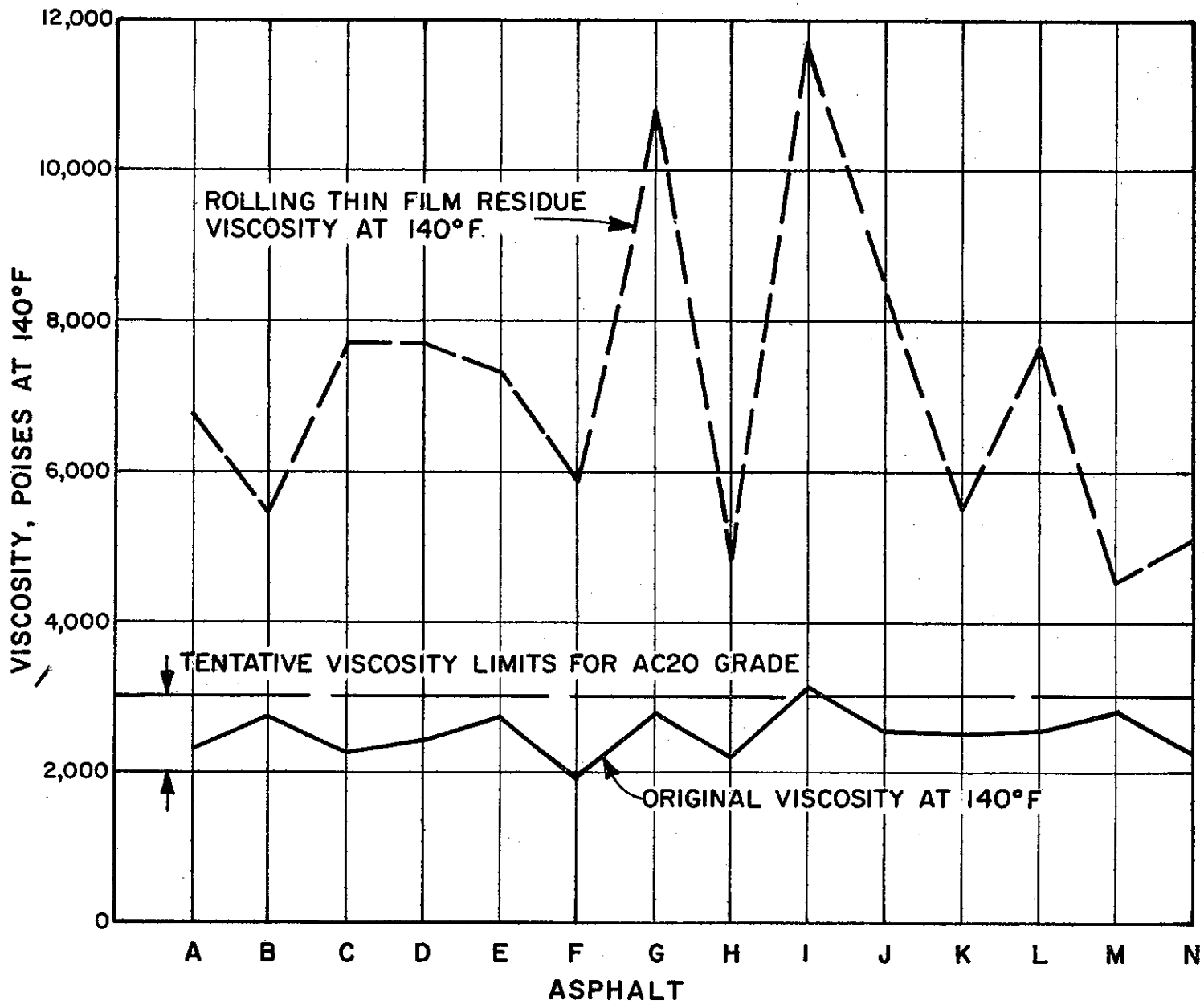


Figure 1

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